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Implicit behavioural change in response to cognitive tasks in Alzheimer's disease

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AD: Alzheimer's disease

OJD: Objective-Judgement Discrepancy

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Introduction: Lack of awareness about condition or neuropsychological impairment is commonly found in Alzheimer's disease (AD). Recently, evidence has been produced which suggests that people with AD are capable of responding to the experience of illness despite limited awareness of their condition. The current study explored whether implicit emotional responses to experiences of failure in cognitive tasks would result in longer term change in behaviour. **Method:** A group of patients with AD were seen one week after doing tasks which previously had been rigged to be too difficult or easy for them, but now were both set at medium difficulty and administered such that the participants decided how long to persist on the task. Task avoidance was determined by relative persistence on the tasks, with the notion that a participant would be more likely to avoid a task if they had previously experienced failure on it in the first session. **Results:** The results indicated that there was no increased persistence based on previous performance. However, when considering initial awareness of performance, differences between tasks became significant. Patients reacted to the number of errors during the second session, stopping tasks after a sequence of errors. There were no self-reported changes in motivation or enjoyment in response to task failure. **Conclusions:** These findings suggest that implicit learning of task valence may be compromised in AD, but that initial moments of awareness may influence long term adaptation in unaware patients.

1. Introduction

Lack of awareness about illness, cognitive impairments or reduced neuropsychological performance is a common feature of Alzheimer's disease (AD) (Mograbi et al., 2012, Rosen, 2011; Starkstein et al., 2007). Here the term anosognosia, originally coined by Babinski (1914), is an appropriate label for these phenomena because of prominent, but non-exclusive (considering the role of psychosocial influences, such as premorbid personality and social context; Clare, 2004), neurobiological causation. Nevertheless, despite the etymology of this term implying lack of knowledge of disease, recent studies have shown that people with AD are capable of responding to the experience of illness despite limited verbally expressed awareness of their condition. This has been observed in terms of emotional reactivity to memory-related words in a Stroop paradigm (Martyr et al., 2011) and normal emotional reaction to task failure (Mograbi et al., 2012), with similar findings being reported in anosognosia for hemiplegia (Fotopoulou et al., 2010; Nardone et al., 2007) and psychosis (Beck et al., 2004). The term 'implicit awareness' has been adopted as a label for such phenomena (see Mograbi and Morris, 2013).

The notion of implicit awareness suggests that there is behavioural adaptation to illness despite unawareness of deficits, something that so far has been found in clinical situations (Orfei et al., 2007, Mograbi & Morris, 2013). For example, it has been observed that patients with hemiplegia may avoid activities that rely on use of both hands despite being anosognosic about their paralysis (Bisiach and Geminiani, 1991, Cocchini et al., 2017). They may also refuse to acknowledge problems, but comply with the treatment, remaining in hospital to receive care (Prigatano and Weinstein, 1996), including staying in bed or using a wheelchair (Bisiach and Berti, 1995). Considering this, behavioural adaptation despite limited unawareness may be used as an important treatment tool, for example to foster patient adherence and compliance. In terms of experimental research, however, very few studies have explored this topic. Their findings suggest that some patients with anosognosia for hemiplegia may show motor adjustment to their condition, for example performing actions which could be done either with one or two hands in a manner consistent with their paralysis (Cocchini et al., 2010; Moro et al., 2011).

In the case of AD, whilst patients have noted adjustment to condition (e.g. increased calendar use) despite unawareness of impairments (Mograbi and Morris, 2013), experimental evidence is even sparser. One study by Moulin and colleagues (2000) using word lists showed that although people with AD were inaccurate in their prediction of memory performance in terms of verbal judgements, they nevertheless allocated their study time appropriately in relation to the actual performance. Exploring a different topic, a study by Cottrell and Wild (1999) suggested that patients with AD may implement voluntary and self-initiated driving restrictions in response to their impairments, and that this behaviour is not particularly associated with awareness of cognitive deficits. While it is possible that these driving adaptations are caused by residual or fluctuating awareness, it is suspected from the way that patients sometimes rationalize their behavioural change that implicit adaptation may be partially related to this phenomenon.

Furthermore, descriptive studies suggest the presence of implicit learning in cases of patients presenting amnesia for declarative memory (Schacter, 1990, 1992) in spite of limited awareness of their capacity, and that this capacity can extend to affective content of stimuli. An early anecdote illustrating this point was presented by Claparede (1911). He used a pin to prick the hand of a patient while shaking hands with dense anterograde amnesia. The next day, the patient could not remember the events of the day before or Claparede itself, but even though refuse shaking his hands. When asked about a reason, the patient gave an explanation, which was unrelated to the previous experience. Supporting this report and the idea of affective leaning in spite of declarative memory deficits, Tranel and Damasio (1993) described the case of a patient with severe anterograde amnesia for all types of knowledge, including faces, who was able to form bonds with new people differentially depending on the affective valence they exhibited. For example, the patient would choose, in a forced-choice paradigm, the face of an experimenter who had displayed positive affect towards him over another who had displayed negative affect in spite of not being able to recognize faces. However, this implicit learning dissipated with time, and at a four year follow-up the patient responded indiscriminately to the faces. In a related field, implicit learning of affective valence has long been studied with amnesic patients using fear conditioning paradigms, and studies suggest that this ability is preserved even in profoundly amnesic patients (Weiskrantz and Warrington, 1979; see Woodruff-Pak, 1993, for a study with patient H.M.). More recently, it has been shown that people with AD experience prolonged states of emotion that persist beyond their declarative memory of exposure to emotional material (Guzman-Velez et al., 2014).

In summary, despite a limited number of studies, such results are suggestive of implicit processing of information about illness and failure in tasks leading to emotional responses and behavioural change. These findings are consistent with the Cognitive Awareness Model (CAM), developed to explain different phenomena associated with anosognosia in AD (Agnew and Morris, 1998; Morris and Hannesdottir, 2004; Morris and Mograbi, 2013; Mograbi and Morris, 2014). The CAM postulates that anosognosia is heterogeneous, with potential executive (e.g. error monitoring deficits) or mnemonic (e.g. lack of updating of personal information) presentations. Nevertheless, the model also suggests that the presence of relatively well preserved mechanisms for error detection allow information about deficits or condition to be relayed to a parallel implicit route which bypasses consciousness, resulting in affective and behavioural regulation in the absence of metacognition. This notion has been explored experimentally in a study (Mograbi et al., 2012) that investigated emotional reactivity in response to performance on computerized memory or reaction time tasks in which difficulty levels were manipulated to make them either very easy or frustratingly hard for each participant, designated respectively as 'success' or 'failure' conditions. An AD group showed lack of awareness about performance relative to controls. In comparison, the two groups showed similar emotional reactivity as measured using self-report and filming of facial expressions, with equally pronounced negative emotional expressions on the failure condition. These findings suggests that affective valence of failure experience was processed even with impaired awareness of performance, indicating a dissociation of implicit processing of information and awareness (for studies showing that emotional features of stimuli modulate awareness, see Besharati et al., 2016, D'Imperio et al., 2017, Bertrand et al., 2016).

The current paper explores whether implicit emotional responses to experiences of failure would result in longer term change in behaviour as suggested by previous everyday observation, but not yet studied experimentally. Would the AD group in the study by Mograbi et al. (2012) show relative changes in their future response to the 'success' or 'failure' tasks, despite their limited awareness of performance? To investigate this issue, the AD participants from the previous study were seen after one week and the tasks administered again. Here the previously 'easy' or 'difficult' tasks were now both set at medium difficulty and were administered such that the participants decided how long to persist on the task. The level of task avoidance (i.e. less persistence) associated with failure was determined by relative persistence on the tasks, with the notion that a participant would be more likely to avoid a task if they had previously experienced failure on it in the first session, indicating implicit affective learning. In addition, self-reported task motivation and enjoyment were measured, with the idea that previous experience of failure could impact on these variables.

2. Methods

2.1. Participants

Twenty two participants with mild to moderate AD were included in the study, recruited either from the South London and Maudsley / Institute of Psychiatry Biomedical Research Centre (BRC) Dementia Case Register or from the St George's Healthcare NHS Trust (London) Dementia clinic. Diagnosis was made using DSM-IV criteria for Dementia of the Alzheimer’s type (American Psychiatric Association, 2000), and patients were included if they had Mini-Mental State Examination (MMSE; Folstein et al., 1975) scores of 18 or above (Mungas, 1991; NICE, 2006). Consecutive patients who fulfilled the study eligibility criteria were approached. Exclusion criteria were current neurological disorder (other than AD, also excluding cases with mixed AD and vascular dementia), history of head injury resulting in loss of consciousness for more than an hour, history of alcohol or substance abuse (based on ICD-10 criteria), history of diagnosed psychiatric disorder or current comorbidity. Table 1 provides the clinical and demographic characteristics of the participants.

Insert Table 1 about here please

2.2. Procedures

2.2.1. Overview

Two success-failure manipulation (SFM) computerized paradigms were used (Mograbi et al., 2012; for a full account of the development of the tasks, see Mograbi et al., 2014), one measuring reaction time and the other memory, each with two alternative but distinctive versions. The study consisted of two sessions. Results from the first session have been published previously and indicated that AD patients showed poor awareness of performance relative to controls but preserved emotional reactivity to failure (Mograbi et al. 2012). The focus of the current study is task persistence in the second session, but since this is related to failure in the first session, the configuration of the computer tasks is described for both sessions:

1st session – Titration and Success/ Failure Manipulation: A titration technique was used in order to match task difficulty across participants, with the ability of each participant first established individually by systematically increasing difficulty levels until consistent failure occurred. The participants then went on to a Success-Failure manipulation phase in which Success or Failure conditions were established by setting the difficulty level respectively below or above this performance threshold. For each participant, one of the alternative versions of each of the two tasks was set with a threshold that led to high levels of task failure and the other at a level that led to a high level of success. Participants were not informed that levels of difficulty would be manipulated and the manipulations were disguised successfully (see Mograbi et al., 2012 for details);

2nd Session – Titration and Persistence Evaluation: This was the main focus of the current study, in which the same tasks were administered again to the AD group after one week. The one week time gap was chosen after piloting procedures (n = 4) indicated that by then the patients would have no recollection of task performance. After doing the practice trials in the second session, patients were asked if they were familiar with this task. On questioning, two patients had no recollection of the previous testing, while two had a feeling of familiarity but were unable to describe their previous performance.

In this session, the difficulty level was determined by repeating the titration procedure to take into account potential variation in performance between sessions, due to factors such as practice. After the titration, all tasks were set at 50% level of performance, with the software controlling difficulty levels over a block of trials, with 5 trials below and 5 trials above the participant's threshold in each, arranged in a pseudo-random order. This overall approach was designed so that all patients had a sufficient level of difficulty to promote motivation to continue, but without making the task too easy so as to mask any prior experience persistence effect. The tasks were presented in the same order as in the first session (i.e. the Mograbi et al., 2012 study), with the order of experiments and conditions being quasi-counterbalanced between the participants as described previously (Mograbi et al., 2012).

For the sake of simplicity, tasks in the second session are referred to by their condition in the first session (Success or Failure), even though in the second session (Persistence phase) these tasks were set up to have the same level of success.

2.2.1. Experiments

In both experiments, parallel versions of the tasks, made distinctive by non-essential task features, were used, avoiding task-related effects on motivation. These are described below.

Experiment 1 – Reaction Time

In version 1, a car appeared on a computer screen moving across the screen from left to right, with the participants having to 'stop' the car as soon as it appeared by pressing a single centrally located box housed button. If pressed in time, a 'traffic warden' appears and there is a 'clink' noise. In version 2, objects (e.g. ball, egg or vase) appeared to fall from the 'top' of a building and participants had to 'catch' the object by pressing the button, success signified by a 'hand' appearing and the same 'clink' noise. For both tasks there was a warning tone and after 164 ms the object appeared. If the participant failed to respond in time, a 'croak' noise signalled failure. The practice trials ensured that the patients understood the meaning of the auditory feedback. Participants were told not to press the button before they saw the target or between trials. Task difficulty overall was manipulated by varying the object's speed, quantified by pixels moved per screen refresh, from 12 (slowest) to 42 (fastest).

Experiment 2 – Memory

Memory span test procedures were used, again with material presented on a computer screen. For version 1, between 1 to 10 identical everyday objects (taken from a set of photographs; e.g. alarm clocks and baskets) were displayed scattered across the screen. For each trial the objects were highlighted in a random sequence using a red square surround and immediately after participants had to point to the same objects in sequence. For version 2, participants had to listen to a sequence of digits ranging from 0 to 9, presented individually in the center of the screen, and immediately repeat it back sequentially to the experimenter. For both versions, completely correct responses were indicated by a green visual 'tick' and an auditory 'clink', and failure by a red cross and a 'croak' sound. The shortest sequence was one and the longest ten objects/digits.

2.3. Measures

Figure 1 shows the order of procedures and assessments.

Insert Figure 1 about here please

2.3.1. Task Persistence

Persistence was measured by how long participants did each task during the Persistence Evaluation session. In this session, the computer tasks had no time limit and patients were instructed that they could stop the task whenever they wanted. It was also emphasized that participants did not have to do the task for a minimum amount of time (e.g. "Do this task for as long as you want, there is no expected minimum amount of time; it is really up to you"). The time was recorded from the end of Titration to when the patients stopped the task. However, on three occasions, participants asked to stop the task before the end of the titration phase and for these cases the persistence time was considered to be zero seconds. Because of the possibility that the patients would forget the instruction to stop when they wanted to, they were prompted again with the instructions one minute after the start of the Persistence Evaluation phase, and every four minutes thereafter (5, 9, 13 and so on).

2.3.2. Self-reported Motivation/Enjoyment

A four-point scale was used to rate motivation and enjoyment to do each computer task, with points labelled as follows: 0, “not at all”; 1, “a little”; 2, “somewhat”; 3, “a lot”. During the first session, ratings were taken immediately after the practice trials but before starting the Titration, when the participants were already familiarized with the task demands. The participants were asked: “How motivated are you to do this task, from not at all to a lot?” and “How do you think you will enjoy doing this task, from not at all to a lot?” Further explanation was given if needed. Additionally, because answers to these questions could be influenced by demand characteristics, participants were told after questions and before their response: “Please answer honestly, if you think you are not motivated/will not enjoy it, you can say this. It is not a problem.” Participants were asked the same questions in the Persistent Evaluation session, again immediately after practice trials but before starting the second titration. As a complementary measure, participants’ motivation and enjoyment were also rated by the experimenter. The ratings were completed immediately following the self-rating procedure and used the same four-point scale. This investigator rating considered not only the verbal response of participants but other details such as tone of voice, speed of response and facial expression.

2.3.3. First Session and Background Variables

Awareness of performance was not measured in the Persistence Evaluation session, since it was not the focus of the study to determine if participants were aware or not of current performance. Nevertheless, during the first session an Objective-Judgement Discrepancy (OJD; Agnew and Morris, 1998) method had been used. Immediately after the success or failure conditions, participants were asked to rate how well they did on the task. Ratings were done using a 0% to 100% scale, with 0% meaning all trials were wrong and 100% all trials correct. Estimations ratings were subtracted from the actual performance to form the OJD score (positive scores indicating overestimation of performance). Emotional reactivity was also measured in this first session (see Mograbi et al., 2012 for more details). In summary, a self-report questionnaire was completed measuring four emotional dimensions (frustration, disappointment, embarrassment and boredom), and these were combined in a general index of negative/positive self-reported emotion. In addition, facial expressions were filmed and rated using the Facial Action Coding System (FACS; Ekman and Friesen, 1978).

Unawareness about the dementia condition in general was also measured in the sample with the Anosognosia Questionnaire for Dementia (AQ-D; Migliorelli et al., 1995). The AQ-D relies on direct questioning of patient and informant, contrasting their answers to questions covering functional and behavioural problems commonly found during the course of dementia. Finally, the CERAD word list memory task was used, generating scores for immediate recall, delayed recall, recognition and number of intrusions (Morris et al., 1989).

2.4. Ethical Issues

The project was approved by the South London and Maudsley/ Institute of Psychiatry Ethics Committee (Research Ethics Committee number 08/H0807/6). All participants provided informed consent, with caregivers also giving their agreement for the patient to take part.

2.5. Statistical Analysis

All analyses were done separately for each experiment. To ensure that the experimental manipulation succeeded, a 2x2 repeated-measures ANOVA was calculated, with task type (failure and success) and session (first and second) as within-subject factors. To explore persistence in relation to task type, a one-tailed paired samples t-test was calculated to compare the time spent between the tasks that had been used previously in either Success or Failure conditions. These tests were recalculated as ANCOVAs to allow the inclusion of covariates, exploring their impact on differences in persistence on Success and Failure tasks. Because of limited statistical power, only one covariate was included per analysis. A total of nine ANCOVAs were calculated, including one of the following variables as a covariate: cognitive level (MMSE), awareness of condition (AQ-D), delayed recall (taken from the CERAD test), emotional reactivity in the first session (intensity of facial expressions, repertoire of facial expressions and self-reported emotion) and awareness of task performance in the first session (OJD scores for Success and Failure tasks). Cognitive level and awareness about condition were included because these general factors could be linked to decreased persistence. Delayed recall was included because better memory could result in explicit recall of the first session, influencing task avoidance in the second session. The influence of emotional reactivity was explored because stronger reactions in the first session could predict more pronounced avoidance of tasks subsequently. Finally, the aim of analyzing the relationship with task awareness (OJD) was to determine if changes in task avoidance were associated with perception of performance in the first session (i.e. encoding how well they actually did in the task).

Influence of failure during the tasks in the second session was calculated as a complementary analysis. This was investigated because even though overall performance in the Persistent Evaluation session was controlled at 50%, this was done with a block of 10 trials (5 failure/5 success) coming in random order. During the testing it was noticed that patients would frequently stop the tasks after a sequence of trial failures. In order to test this statistically, the number of errors in the last 3 trials before participants stopped was registered and a one sample t-test against the expected mean of 1.5 failures (equal number of errors/correct answers) was calculated. This was done to explore if participants were sensitive to errors in the second session and if this could be a potential explanation for stopping the tasks.

Finally, to investigate if the change in motivation and enjoyment from the first to second session was significantly different for the previously Failure task in comparison to the previously Success task, a motivation/enjoyment change score was created (both for self-report and investigator ratings) according to the following calculation: Change 2nd session = motivation/enjoyment at start of 2nd session – motivation/enjoyment at start of 1st session. These two scores were then compared using a Wilcoxon Signed-Rank Test (Wilcoxon, 1947). This analysis was structurally equivalent to a parametric two-way ANOVA with time and condition as factors. In this analysis, to account for the effect of multiple testing, p-values were adjusted by Bonferroni-Hochberg corrections (Hochberg, 1988) within each experiment.

3. Results

Data from the first session have been reported in Mograbi et al., 2012, but because it provides important context for the current study, exploring the effectiveness of the mood induction procedure, results are reported again.

3.1. Experiment 1 – Reaction Time

Table 2 presents awareness of performance (OJD) in the first session and performance in the first and second sessions. There was a significant interaction between session and performance ($F (1, 20) = 90.75$, $p < .001$). The experimental manipulation led to markedly different performances in the first session ($p < .001$), but, as planned, not in the second session ($p = .663$). In terms of awareness of performance in the first session, AD patients seem to underestimate their performance in the success condition and overestimate in the failure condition.

Insert Table 2 about here please

3.1.1. Persistence

A one-tailed paired samples t-test indicated no significant differences in the Persistence time when comparing each condition (t (21) = 0.99, $p = .167$; Figure 2). The above analysis was repeated using ANCOVAs to allow the inclusion of covariates. There was no change in results after controlling for cognitive level, awareness about condition, emotional reactivity, delayed recall or awareness of performance of the Failure reaction time task in the first session. The difference in time doing the tasks in the second session became significant after controlling for awareness of performance (OJD) of the Success reaction time task in the first session ($F (1, 20) = 6.53$, $p = .019$). There was also an interaction with this factor ($F (1, 20) = 5.50$, $p = .029$), with more time in the second session doing the Success task but less doing the Failure task with increased awareness of the Success task in the first session (B Success task: 2.14; B Failure task: -3.40).

Insert Figure 2 about here please

3.1.2. Numbers of Errors before stopping

In the last 3 trials before participants stopped the tasks, they had an average of 2.18 (SD: 0.96) errors in the Success task and 2.04 (SD: 1.00) in the Failure task. A one-sample t-test indicated that these values were significantly above an expected mean of 1.5 errors (Success task t (21) = 3.34, p = .003; Failure task: t (21) = 2.56, p = .018).

3.1.3. Motivation and Enjoyment

Table 3 presents summary data of motivation and enjoyment before tasks in each session. Wilcoxon tests revealed no significant differences between Change scores regardless of outcome and rating method (self-rated motivation z = -0.83, p = .999; self-rated enjoyment z = -0.09, p = .999; investigator-rated motivation z = 0.00, p = .999; investigator-rated enjoyment z = -1.16, p = .976).

Insert Table 3 about here please

3.2. Experiment 2 – Memory

Table 4 presents awareness of performance (OJD) in the first session and performance in the first and second sessions. There was a significant interaction between session and performance (F (1, 20) = 45.42, p < .001). In agreement with the experimental manipulation, there were significant differences in performance in the first session (p < .001), but not in the second session (p = .775). Patients show a swing in estimations of performance similar to the observed during Experiment 1, but with higher scores (for a full discussion and comparison with control data, see Mograbi et al., 2012).

Insert Table 4 about here please

3.2.1. Persistence

A one-tailed paired samples t-test indicated no significant differences in the time spent in each condition (*t* (21) = 1.49, p = .075; Figure 3). Using ANCOVAs the results remained unchanged after controlling for cognitive level, awareness about condition, emotional reactivity or delayed recall, but there were changes when awareness of performance (OJD) in the first session was included as a covariate. After controlling for awareness of performance (OJD) of the Failure memory task in the first session, there was a significant difference between times spent on tasks (F (1, 20) = 5.63, p = .028) (B Success task: 3.36; B Failure task: -4.83). There was also a significant difference after controlling for awareness of performance (OJD) of the Success memory task in the first session (F (1, 20) = 9.36, p = .006). In addition, there was an interaction with this factor (F (1, 20) = 6.55, p = .019), with more time in the second session doing the Success task but less doing the Failure task with increased awareness of the Success task in the first session (B Success task: 6.61; B Failure task: -2.63).

Insert Figure 3 about here please

3.2.2. Numbers of Errors before stopping

In the last 3 trials before participants stopped the tasks, they had an average of 2.00 (SD: 0.62) errors in the Success task and 1.95 (SD: 0.84) in the Failure task. A one-sample t-test indicated that these values were significantly above an expected mean of 1.5 errors (Success task: *t* (21) = 3.80, p = .001; Failure task: *t* (21) = 2.53, p = .019).

3.2.3. Motivation and Enjoyment

Table 5 presents summary data of motivation and enjoyment before tasks in each session. There were no significant differences between change scores regardless of outcome and rating method (self-rated motivation z = -0.06, p = .999; self-rated enjoyment z = -0.28, p = .999; investigator-rated motivation z = 0.25, p = .999; investigator-rated enjoyment z = -0.85, p = .999).

Insert Table 5 about here please

4. Discussion

In summary, the study showed that a week after performing a series of tasks with varied degrees of success there were no differences in persistence, contrary to the study's main hypothesis. Nevertheless, after awareness of performance in the first session was used as a covariate, results showed less persistence on the task that had led to worst performance in the first session. There was also a propensity to give up following failure in the second session. In terms of self-reported motivation/enjoyment, there were no differential changes from the first to second session.

4.1. Persistence

In both experiments, there were no significant differences in persistence for Success relative to Failure tasks. Means were in the predicted direction but high variability meant the results were not significant. Nevertheless, effect sizes found were small (Cohen's d = .16 and .31 for reaction time and memory tasks respectively). The rationale behind the use of distinctive tasks in opposite conditions was that patients would associate each task with relative success or failure in the first session, and, based on this experience, exhibit task preference in the second session. The hypothesis of task preference in AD was based on anecdotal evidence, but the lack of such an effect is not entirely surprising considering that associative learning processes, such as classical conditioning, have been found to be impaired in AD (Hoeffer et al., 2008; Woodruff-Pak et al., 1996). However, it is not clear whether deficits in conditioning in AD are mainly due to impaired response to unconditioned stimuli or a specific impairment in learning mechanisms (Hamann et al., 2002). Considering results of a previous study, AD patients were able to exhibit emotional responses to these tasks (Mograbi et al., 2012), so it seems that the absence of task avoidance in the second session may be credited to impairments specific to learning. An important finding relating to understanding behavioural change in the current study was the association of awareness of task performance in the first session with persistence in the second session, with better awareness predicting more persistence later on. This result was consistent for awareness of success for both experiments, and also present for failure in the memory tasks. The fact that this result was stronger for awareness of success tasks may suggest that, rather than being a case of task avoidance, this effect would be more aptly described as an increase in persistence following success. While this finding is counter-intuitive initially, as it might suggest that acquired implicit response to failure depends on awareness, there are various ways of explaining it.

Awareness provides a stimulus with wider contextual linking and correlational abilities. In other words, when we are aware of something we become aware of its relationship with other things (Weiskrantz, 1997). One of the potential reasons for why initial awareness was associated with long term behavioural change is the complexity of the learning involved. Learning the valence of the computer tasks is arguably more complex than basic implicit learning, such as in classic conditioning. For example, knowledge about emotional states caused by the tasks involves an attributional level, which may be more fully accessed with awareness. According to this perspective, awareness would be needed to integrate information fully, a global workspace in which different sources of information (e.g. cognitive, emotional, behavioural) are linked (Baars, 1997). It is also possible that the experience of initial failure with awareness has a longer lasting consequence on behaviour than without it, and this may be particularly important for cases when subsequent explicit recollection of stimulus properties is not possible; perhaps with shorter time gaps initial awareness would not be such a relevant factor. Here the distinction between phenomenal and access consciousness may prove relevant (Block, 1995). Although the immediate experience of failure (i.e. phenomenal consciousness) may lead to short term adaptation, only an initial moment of reasoning and cognitive control (i.e. access consciousness) would lead to long term behavioural change. Finally, it is also probable that the emotional impact of the tasks was not strong enough to cause long term implicit learning on its own, and richer encoding of experience was necessary, even if this information subsequently degraded and led to impaired recollection of previous contact with the tasks.

Whatever the case may be, the study shows that patients are capable of exhibiting long term avoidance to tasks where they had performed poorly even without memory of previous performance, given that at the initial interaction with the tasks patients are aware of their performance. That is, once the information is acquired and processed within awareness, with widespread linking and improved appraisal of contextual cues, it exerts implicit effects on behaviour even if explicit memory of the tasks is unavailable. This may be particularly important from a clinical point of view, highlighting the need of providing information to patients within awareness for long term adaptation in relation to treatment to occur.

4.2. Number of Errors before stopping the Tasks

It is also noteworthy that in both experiments participants consistently stopped the tasks after a sequence of trial failures, at a level significantly above chance. For both experiments, number of errors before stopping is higher for tasks in which AD patients previously succeeded, although this is just a non-significant marginal difference. It is possible that the effects of previous performance are more evident in a context of failure, and perhaps if tasks had been set up for failure instead of being neutral (i.e. 50% of success) in the second session, more marked differences in terms of task avoidance would have been evident. In any case, this finding suggests that AD patients' task avoidance was also influenced by performance in the second session, with failures leading to giving up the task (i.e. less persistence). Even though awareness of performance in the second session was not recorded, this may indicate that patients are able to monitor their performance at least on a trial-by-trial basis, and that successive experience of failure decreases task persistence in AD, consistent with the study's hypothesis. This is also in agreement with previous studies on metacognition in AD, which indicate that patients can revise estimations of performance following feedback, but that after a delay this information degrades and estimations get back to pre-testing levels (Ansell and Bucks, 2006; Souchay, 2007; Stewart et al., 2010). This seems to suggest that unawareness in the current sample may be caused more by a problem of integration and consolidation of information than by deficits in error processing. This highlights, clinically, how patients may be able to respond to feedback about performance, at least in the short term.

4.3. Enjoyment and Motivation Ratings

Comparison of pre-testing motivation and enjoyment ratings from the first and second sessions indicated no significant differences regardless of experiment and rating type (self/investigator), with inspection of Tables 2 and 3 indicating a trend towards AD patients resetting their ratings in the second session to pre-testing levels of the first session. This suggests that, at least at an explicit/declarative level, patients did not exhibit any long term changes in motivation or enjoyment in response to the initial experience of failure.

4.4. Limitations and Summary

A feature of the current study is that in the second session of the study there were no formal measures of memory of the first session. This was so as not to risk biasing the participants' expectations concerning the nature of the current study and was also on the basis that the pilot work had shown that patients with similar levels of neuropsychological impairment were clearly unable to remember the tasks or their performance after the one week gap. In the actual study, only one participant spontaneously expressed a vague feeling of familiarity regarding the tasks but was unable to provide details about performance and his scores in the second session were in no way atypical. Moreover, ANCOVAs with memory did not indicate an influence of this factor in task persistence. Measures of executive functions, in particular perseverance, would have been useful and could be employed in future investigations about this theme. The current study did not have a control group, again based on the converse idea that the controls would remember task performance in a second session one week after the first and so the study would not be measuring implicit adaptation in this group. Further studies would be of interest using these procedures with very long time intervals for control participants, sufficient to cause forgetting of the task experience. Finally, the sample studied was limited, both in terms of the heterogeneity of cognitive impairment and actual size, which could have contributed to the null finding when comparing persistence for success and failure. Nevertheless, as indicated above, the effect sizes obtained were small, such that if there were differences for this patient type, it might be that only much larger samples would deliver significant results.

4.5. Conclusions

In summary, the results indicated that experience of failure influenced persistence, and that implicit task avoidance can occur one week after exposure to failure, but this is related to the degree of initial awareness of performance. These findings suggest that initial moments of awareness may influence long term adaptation. In the context of AD, in which variations of preserved awareness or monitoring of task performance are present, the extent of preservation may play an important role in adaptation, even if memory of experience of tasks is lost. Future studies are needed to expand knowledge in this issue.

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Table 1. Demographic and clinical profile of the sample

Variable		People with AD (n=22) Mean (SD) / Range
Age		80.1 (6.7) / 66–89
Gender*		13 / 9
Years of education		11.3 (3.2) / 4–18
MMSE		23.4 (2.9) / 18–29
CERAD	Immediate recall	11.4 (4.1) / 2–19
	Delayed recall	1.4 (1.3) / 0–4
	Recognition	15.1 (3.5) / 9–20
	# of Intrusions	2.0 (1.7) / 0–6
AQ-D	Informant rating	31.1 (11.6) / 12–55
	Patient rating	10.9 (7.7) / 2–35
	Discrepancy score	20.2 (11.7) / 2–51

* # female/ male

Table 2. Performance and awareness of performance (OJD) during Experiment 1 (reaction time) in the first and second session

	1st session Mean (SD)	2nd session Mean (SD)
Success condition		
Estimation (%)	58.3 (16.3)	–
Performance (%)	77.5 (7.7)	47.1 (7.7)
OJD (%)	**-19.2 (16.2)**	–
Failure condition		
Estimation (%)	43.1 (23.5)	–
Performance (%)	28.1 (10.5)	47.7 (11.8)
OJD (%)	**15.0 (23.8)**	–

Table 3. Self-rated and investigator-rated motivation and enjoyment before reaction time tasks in the first and second session

	Self-rated		Investigator-rated	
	Success task	Failure task	Success task	Failure task
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Motivation				
Before task first session	2.27 (0.63)	2.18 (0.79)	1.95 (0.72)	1.82 (0.85)
Before task second session	2.23 (0.87)	2.00 (0.93)	1.77 (0.68)	1.64 (0.80)
Change score	-0.04 (0.65)	-0.18 (0.79)	-0.18 (0.59)	-0.18 (0.79)
Enjoyment				
Before task first session	2.00 (0.87)	2.04 (1.00)	1.91 (0.75)	1.95 (1.00)
Before task second session	2.00 (0.93)	2.04 (0.79)	1.82 (0.85)	1.54 (0.74)
Change score	0.00 (1.02)	0.00 (0.82)	-0.09 (0.81)	-0.41 (0.80)

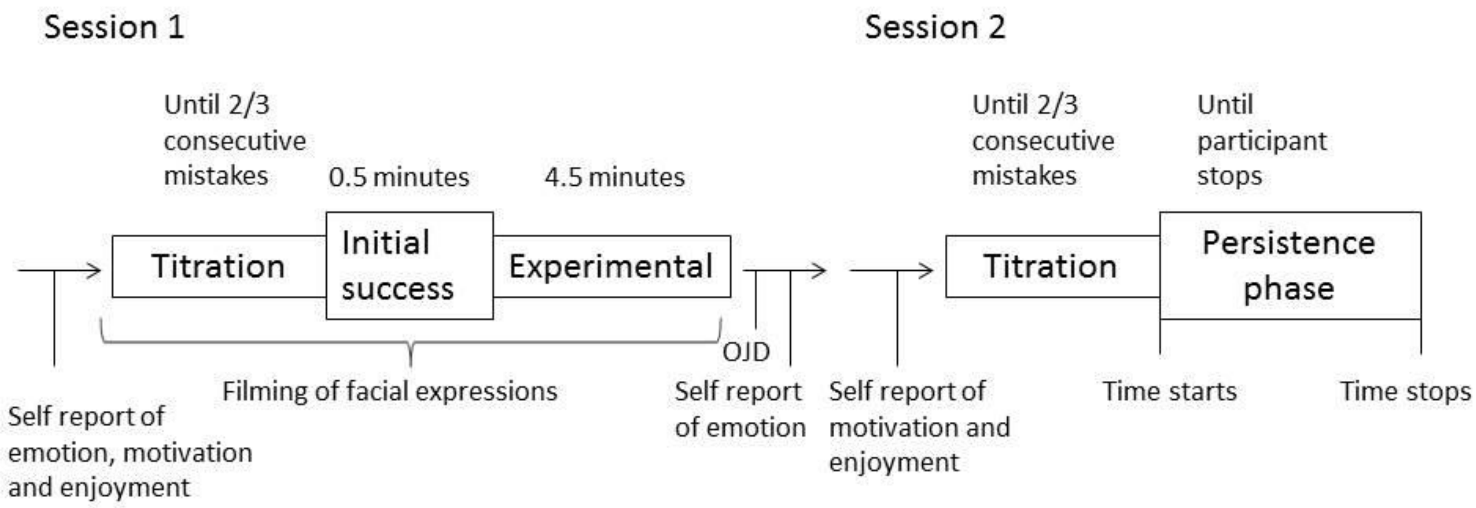
Table 4. Performance and awareness of performance (OJD) during Experiment 2 (memory) in the first and second session

	1st session Mean (SD)	2nd session Mean (SD)
Success condition		
Estimation (%)	60.0 (16.7)	–
Performance (%)	78.2 (7.9)	43.7 (12.9)
OJD (%)	**-18.3 (15.1)**	–
Failure condition		
Estimation (%)	33.0 (20.1)	–
Performance (%)	34.4 (7.9)	44.7 (16.3)
OJD (%)	**-1.4 (21.0)**	–

Table 5. Self-rated and investigator-rated motivation and enjoyment before memory tasks in first and second session

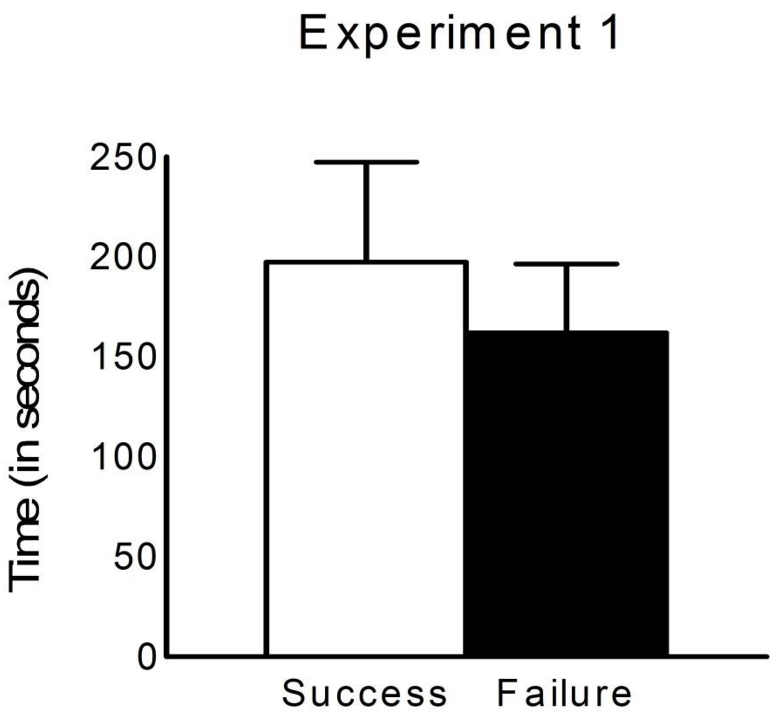
	Self-rated		Investigator-rated	
	Success task Mean (SD)	Failure task Mean (SD)	Success task Mean (SD)	Failure task Mean (SD)
Motivation				
Before task first session	2.23 (0.68)	2.09 (0.81)	1.91 (0.75)	1.64 (0.85)
Before task second session	2.14 (0.83)	2.00 (0.87)	1.91 (0.92)	1.59 (0.96)
Change score	-0.09 (0.61)	-0.09 (0.81)	0.00 (0.76)	-0.05 (0.78)
Enjoyment				
Before task first session	2.14 (0.89)	1.91 (0.97)	1.82 (0.85)	1.50 (0.91)
Before task second session	2.14 (0.83)	1.86 (0.94)	1.73 (0.93)	1.59 (0.91)
Change score	0.00 (0.62)	-0.05 (0.65)	-0.09 (0.68)	0.09 (0.68)

Figure 1. Protocol for Experiment 1 (Reaction time tasks) and Experiment 2 (Memory tasks)



For Experiment 1 the titration phases continued until 3 consecutive mistakes, whilst for Experiment 2 this was for 2 consecutive mistakes. In Session 1, order of tasks and assignment of task version to condition (success or failure) was counterbalanced, with the constraint that participants never did two failure tasks consecutively. Order of tasks in Session 2 was the same as in Session 1 for all participants.

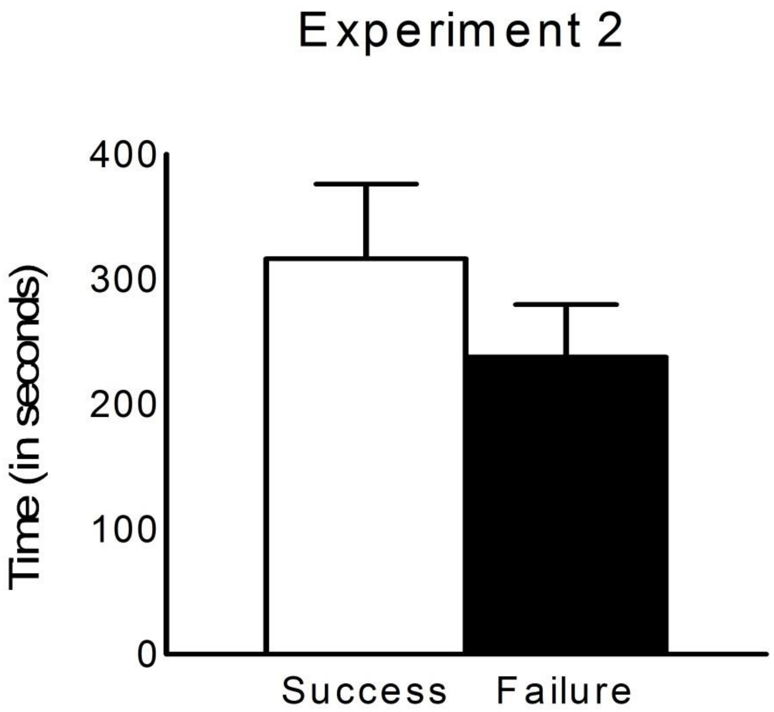
Figure 2. Time spent doing tasks during Experiment 1 (reaction time)



Mean (SEM) time spent doing success task (white bar) and failure task (black bar) during Experiment 1.

There was no significant difference between task types.

Figure 3. Time spent doing tasks during Experiment 2 (memory)



Mean (SEM) time spent doing success task (white bar) and failure task (black bar) during Experiment 2.

There was no significant difference between task types.